BRIDGEWATER STATE UNIVERSITY

The Graduate Review

Volume 5

Article 7

2020

New Innovation in the Flipped Chemistry Classroom

New Innovation in the Flipped Chemistry Classroom[1]

SHAWN LUCE

Introduction

For generations, the traditional model of the classroom has been widely accepted and practiced in schools throughout the United States. By traditional, this means students enter the classroom; the teacher divulges their knowledge to their class, generally by some form of lecture; and students take notes. At the end of class, students are often assigned homework, where they must practice the skills and knowledge discussed from class. This repeats each day, where the teacher provides another piece to the growing puzzle for students to learn. In recent years, with the expansion of technology in the classroom, lecture has taken different forms: educational movies and lectures from professionals, students taking notes electronically, and virtual reality tours, to name a few. In each of these formats, technology is being used to supplant the traditional model of education, where all learning takes place in the class, and students must practice individually, without the aid of the teacher. The main purpose of this project was to explore how a flipped classroom would manifest in a chemistry classroom setting. The flipped classroom is one where students preview traditional notes on their own and then the practicing of skills is done in class. Flipping a class can take many different forms, depending on the class content. This model has been applied to the chemistry classroom, arguably a challenging course that may seem daunting for students to learn and practice their skills. The intrinsic value of a flipped classroom is the teacher is no longer using essential class time to introduce course content. Students learn content outside of class, so that class time is used to practice and enhance skills through the content. Students have direct access to the content; professionals; and not to mention, peers, who are also going through the learning process as well. Throughout this paper, the benefits of a flipped chemistry classroom will be highlighted and expanded upon, representing a model for which other teachers in varying content areas can apply similar ideas.

Purpose Statement

There are multiple benefits to the flipped classroom approach to teaching. First, most students learn at varying paces and in different styles. The lecture videos, used in this chemistry curriculum, allow students to access the notes at their own pace. The videos can be paused, rewound, and watched over again, if the student has the link to the video. This is a more effective approach to lectures. In a traditional classroom, if a student is absent, if they leave the classroom for a bathroom break, or if they need a slower pace for effective understanding, the student may miss crucial information. The flipped classroom provides greater access to more students. The videos also contain closed-captioning for students who are hearing impaired or otherwise benefit from text to pair with audio information. This approach also allows for classroom time to be maximized on practicing skills and reinforcing content. Students in a traditional classroom are given homework problems, where they must take what was taught in class and apply it on their own, often outside of school. In the flipped classroom approach, students hone their skills with the teacher in the room, guiding along the way where needed. The teacher can provide instant feedback and can assist where misunderstandings have formulated.

Questions Guiding This Curriculum Development

The following questions guided the development of the chemistry curriculum, using the flipped classroom approach:

1. How have successfully implemented flipped classrooms been designed?
2. How have the introduction of flipped classroom protocols affected the learning outcomes of students?
3. What do experts recommend?

Review of Related Literature

A review of journal articles, books, and other referenced publications was conducted to investigate the design and benefits of incorporating a flipped classroom. This information is presented below.

The Design of the Successful Flipped Classroom

An essential part to the flipped classroom is the way in which it is designed. There are potentially limitless ways to flip a classroom, but research has shown a successful scheme that works to the greatest benefit to students. Two criteria must first be met by the students of a flipped classroom: students have fully prepared for in-class activities while outside of school, via reading texts, watching videos, or another instructional process, and students are in the physical classroom when activities are performed (Pérez, Collado, Garcia de los Salmones, Herrero, & Martin, 2019). What this means is that students are provided some learning opportunity that they must complete while outside of the classroom. Where this homework would traditionally be viewed as practice, in a flipped classroom, this is exemplified by instructional resources. When students are in the actual classroom, learning takes the form of activities, practice problems, applications of the material, and other hands-on approaches. It is crucial for the success of the students that they prepare themselves before the flipped classroom activity begins, just like in a traditional model, where students must practice skills based on what was taught in class. In the flipped classroom experience, however, students are able to receive immediate feedback from the teacher, who can now be viewed more as a learning coach than direct instructor.

The groups involved in a flipped classroom must also be prepared for what expectations exist. The three groups are the teachers, the students, and those who design the instruction. It is suggested that each group gives their direct feedback on the design, delivery, and evaluation of a flipped class, as each plays a significant role in how the process is created and continues (Miles & Fogget, 2016). The flipped classroom is ever evolving based off the abilities of the instructors and the students, where two flipped classes may look entirely different. By entertaining feedback from each group, the flipped model can continue to improve and adjust as needed. In a way, the flipped classroom offers more differentiation of content for students, improving the general understanding of a class.

The Effects of the Flipped Classroom

Where successfully flipped classrooms have been implemented, there is overlay in the perceived effectiveness of the experience. Typically, what is reported by flipped classrooms with respect to traditional environments are the achievement levels of students, the motivation of students, and the overall learning experience of students. These reports include teacher observation, student feedback, and varying forms of assessment. In a study using high school biology classes, two of four were randomly selected as flipped classrooms, where the other two were kept as traditional classes. The study showed that students who were in the flipped classes typically showed a greater achievement in the biology class. What this study also focused on was how students viewed their course. Those in the flipped classroom reported a preference for lecture videos outside of class and more active approaches to learning while inside the classroom (Leo & Puzio, 2016). The increase in academic achievement is generally mirrored in other classrooms where the flipped approach is used. With more engaging experiences in the classroom, students also show greater levels of motivation to learn (Sezer, 2017) and are better able to internalize their learning through the process or experience (Pérez et al., 2019). Students are not left to sit at their desks and listen to the teacher lecture for a whole class period. Students are moving around and actively participating, which has been viewed as crucial for the overall learning process.

By engaging with the students during activities, teachers are also better able to differentiate for each student. By acting as the learning coach, teachers can better focus on where students need to improve, where misconceptions exist, and where some students need more challenge. Students with learning needs, whether they benefit from an individual pacing plan or an enhancement of course content, are better suited to the flipped classroom. All students can self-pace, to a degree, collaborate with peers with greater ease, and receive instant feedback from their instructor (Altemueller & Lindquist, 2017). This report also showed that students who do struggle in a traditional context may have the greatest benefit with the flipped classroom. As the teacher can focus more of their time one-on-one or in small group settings, students who require additional instructive time with the teacher are provided that opportunity. Gifted students, those with learning difficulties, and all other students benefit in this type of setting.

Methodology

Introduction

This curriculum project focused on the idea of a flipped classroom for a College 2 Chemistry class. The flipped classroom entails direct instruction provided online for students to access outside of school. As students preview notes on their own, this allows for in-class instructional time to be used for topic-specific questions and the practice of skills. Essentially, traditional homework is performed in class, so that students have access to the teacher and immediate feedback while they work. Students can also access course material if they are absent from school and can never really miss any lecture. The flipped classroom also permits students to review, re-watch, and re-learn topics from various lectures throughout the course of the school year.

Procedure

The approach taken to create the flipped classroom was through the use of lecture video notes, posted to a Youtube channel unique to the specific class. Each video is broken down to two- to ten-minute segments, typically separated by topics within an overall unit. A unit may have multiple lecture videos for students to access and watch at their own pace. The lectures were created using the application *Screencastify,* which has a free version, a limit of ten minutes per video, and a maximum of 50 videos can be created per month. When the application is activated, it begins to record the screen of the computer in use. If the computer has microphone access, voiceovers can be created to go along with the recorded visuals. For the purpose of the chemistry classroom, previously made lecture notes were recorded through *Screencastify,* while the voiceover was created. A typical lecture occurred digitally. This screencast was saved and uploaded to Youtube, which contains a unique link to each individual video. Students were provided links to each lecture video.

With *Screencastify* and Youtube selected as the best methods for creating lecture videos, each unit for College 2 Chemistry was divided into multiple video lectures. There are 11 units of instruction for this particular course, and within each unit, are several sections of content within one overarching topic. The videos were planned out by content per unit, so each chapter has between two and five videos. The videos follow a natural break in the notes, dividing each key area. The videos follow through Google Slide Decks that were prepared beforehand, and once a video was deemed satisfactory, it was uploaded to Youtube. This process was taken for each video. In its entirety, creating the collection of lecture videos took about two months, averaging two to three new videos per week. The entire collection of videos can be viewed from a private Youtube channel here: https://www.youtube.com/playlist?list=PLN-nwj1RCR27-z5RgNGYKx-9zS0VuGprZz. Students are provided the links to each individual video as needed. So, if a class were to begin Chapter 1, the first video link would be posted on the class website for the students to access.

Brief Description of Each Video Lesson[2]

Chapter 1-1: What is Matter? - In this lesson, students learn about what is and is not considered matter, how matter is defined, and the different types of matter that are known.

Chapter 1-2: Elements and Compounds – Elements are classified and defined, the Periodic Table is introduced, and compounds are defined by their components. The difference between elements and compounds is explained.

Chapter 1-3: Physical and Chemical Changes and Properties – Physical and chemical properties of substances are defined, and various examples are provided for each. Physical properties are further broken into qualitative and quantitative subcategories, and phase changes between states are explicitly shown to be physical properties. Once properties have been investigated, the class characterizes the differences between physical and chemical changes, how a physical change does not change the original substance, and how a chemical change creates new products.

Chapter 2-1: History of the Atom – While not explicitly set in the current state curriculum standards, it is helpful for students to understand where their thinking of what an atom looks like began, and how it developed as science and technology improved. The class starts with how the Ancient Greeks defined atoms and work up to Bohr's model of the atom. Also described are the three main subatomic particles - protons, electrons, and neutrons – and how each was discovered experimentally.

Chapter 2-2: Atomic Number and Atomic Mass – As stated in the title of the video, atomic number and mass are defined and calculated through various example problems. Students see that in a neutral atom, the number of protons and electrons must be the same, and the number of protons plus the number of neutrons is equal to the atomic mass of an atom.

Chapter 2-3: Isotopes and Average Atomic Mass – Here the class defines what isotopes are, and how, although isotopes are the same atom, they differ in their masses due to differing numbers of neutrons. The class also discusses average atomic mass, as the masses on the Periodic Table are averages based on the abundancies of each element's isotope. Students learn to calculate average atomic mass.

Chapter 2-4: Electrons in Atoms – The planetary model of the atom, as described by Bohr, is viewed and further explained. How electrons surround the nucleus is discussed, as is how electrons operate. The electromagnetic spectrum is viewed and explained, and students build an understanding of how electron movement translates to colors.

Chapter 2-5: Bohr Diagrams and Lewis Dot Diagrams – Both models are introduced here, and students work on how to make each model. The Bohr model of an atom maps all of an atom's electrons in their specific energy levels, while the Lewis Dot model solely focuses on valence electrons.

Chapter 3-1: Discovering the Periodic Table – Students learn how the Periodic Table is constructed and the process of developing it over time. The idea of periodicity, or the tendency to recur at regular intervals, is discussed as it relates to the Periodic Table.

Chapter 3-2: Using the Periodic Table – Now that the table has been viewed, the class looks for patterns in the table. In this lesson, the class investigates how metals, nonmetals, and metalloids are grouped together on the table, and that each column within the table represents elements with similar chemical properties. Group names are also discussed.

Chapter 4-1: Atomic Radius – Now that patterns have been described in the Periodic Table, the class begins to investigate trends that exist in the table. They look at each trend, such as atomic radius, in two ways: going down each group and going left to right across each period. In general, the trends they investigate will show overall increases or decreases moving through the table. For atomic radius, it increases going down a group and decreases going left to right across a period. The reasons for each trend are also explained.

Chapter 4-2: Electronegativity – Another trend within the P.T., electronegativity, is defined and described as it decreases down a group and increases left to right.

Chapter 4-3: Ionization Energy – Similar to the trends before it, the energy required to remove one valence electron is defined, and the trend is explained down a group (decreasing) and across a period (increasing).

Chapter 4-4: Electron Affinity and Ionic Radius – The last two trends are discussed in this lesson, and ionic radius is compared to atomic radius. It is discussed how atoms that lose electrons, typically metals, form cations that cause the radius to shrink, whereas atoms that gain electrons, typically nonmetals, form anions, where the radius increases in size.

Chapter 4-5: Chemical Bonding – Students learn what chemical bonds are, and they investigate ionic and covalent bonding. Students work to construct models for each type of bond as well.

Chapter 5-1: Binary Ionic Compounds – Now that bonding has been discussed, the class looks at how to name various compounds and molecules. They begin with binary, ionic compound naming by following a set of rules. They also identify how to create a compound in its formula-version, given the name of the compound. In this chapter, students learn how to write names based off formulas and create formulas based off names provided for substances.

Chapter 5-2: Polyatomic Ions – Students previously only worked with monatomic ions with binary compounds, so here they define what polyatomic ions are, and how they can be used in naming and formula writing. The students look at a list of some of the more common polyatomic ions they will be using.

Chapter 5-3: Transition Metal Ionic Compounds – As transition metals can vary in their positive charge, names of compounds with transition metals must have a Roman numeral to describe the current state of the metal. This charge is needed to balance the chemical formula. Students also work from the formula to identify what the charge on a transition metal is for a given compound.

Chapter 5-4: Hydrates – Adding one more piece to naming, hydrates are defined and described as ionic compounds that attract water molecules from the air in a whole-number ratio. How to name hydrates is also explained.

Chapter 5-5: Covalent Molecules – The last set of naming rules is shown. Covalent bonding, or the sharing of electrons between non-charged atoms, is discussed, and the naming scheme is described. The students look at how covalent molecules are named differently than ionic compounds.

Chapter 6-1: Balancing Chemical Reactions - Now that students have seen how to write formulas and names for compounds and molecules, they take it one step further: chemical reactions. In this lesson, students learn what reactants and products are, what reaction arrows are, and that the type and number of atoms before a reaction must be the same after the reaction. Students learn that formulas must be balanced first, then coefficients can be placed in front of compounds in order to get the same number of atoms on both sides of the reaction arrow.

Chapter 6-2: Types of Chemical Reactions – Students see five main types of chemical reactions, and how they are characteristically different. Students learn to identify which type of reaction is taking place, based off given reactants and products. The five types described are Synthesis, Decomposition, Single Replacement, Double Replacement, and Combustion.

Chapter 6-3: Factors Affecting Chemical Reactions – In this lesson, students see how some processes can be reversible, and how scientists can control experiments by knowing how to alter reactions. LeChatelier's Principle and Activation Energy are two of the key topics explained.

Chapter 10-1: States of Matter – While students should already have a basic understanding of solids, liquids, and gases, in this lesson, properties of each state of matter are described and compared.

Chapter 10-2: Kinetic Energy and Temperature – Students investigate how kinetic energy, the energy of motion, relates to different states of matter. Temperature is also discussed as a measure of kinetic energy, and the Kelvin unit for temperature is introduced. Students work to convert between Kelvin and Celsius temperatures.

Chapter 10-3: Phase Changes – Now that students have a better understanding of each separate state of matter, they investigate how to change from one phase to another. Two phase-change curves are described: one seen as energy increases over time, and the other as pressure and temperature both change simultaneously.

Chapter 11-1: Behavior of Gases – Gases are the sole focus in this chapter. Students have learned about properties of gases, so they continue to build on this knowledge. Pressure, volume, and temperature are discussed here as they relate to gas molecules. Various pressure units are explained, and students learn to convert between the different pressure units, building on the previous conversion of temperature units.

Chapter 11-2: Gas Laws – Three gas laws are discussed: Boyle's, Charles' and the Combined Gas Law. Students learn about what each law looks like and the various relationships between pressure, volume, and temperature. Students receive examples and practice calculations using any of the three laws discussed in class.

Summary, Conclusions, and Recommendations

The reward for conducting this project was mainly creating a new method of teaching in the 21st century. As technology has become a part of daily life, it can be used to enhance the learning environment. Students no longer need to be taught face-to-face with direct instruction; their learning has grown to a multimodal level. They can learn effectively, through several different means, allowing them to identify which method works best. The challenges to this project were also mainly focused on the technology aspect. While *Screencastify* is user-friendly, it took some time to figure out the full uses of the application, as well as how to upload videos to Youtube. Using the free version of the application also did not allow for editing videos, so if a mistake were made during the recording, or the video glitched in some way, the process had to start over. It was essential to plan out what was to be said and viewed at the same time before beginning the recording.

Conclusions

Through this project, the flipped classroom style of learning can be used to create more engaging class time for students. By having students preview notes outside of class or view videos after a lesson to further cement content, class time can be utilized for skills practice. While the lecture videos have been used sparingly during the 2019-2020 school year, as the videos were being created partway through the year, feedback has been overall positive from students. Students have enjoyed being able to access the class while not in school and appreciate the ease of pacing by pausing to take notes or rewinding to review. Future plans first include a complete rollout in the 2020-2021 school year, using the lecture videos for College 2 Chemistry. During the 2020-2021 school year, the videos will be added to the website EdPuzzle, which allows students to watch the videos just as they do on Youtube, but the teacher can create segments within a video to add questions or comments to check for understanding while students watch and take notes. EdPuzzle also allows a teacher to create a class for their students, so students do not need individual links to videos but rather one link to their EdPuzzle class for the school year. This guided approach to the lecture videos can permit students to gauge their understanding of the content and see what information with which they are having trouble. This can fuel content-related discussion for the next class.

Recommendations

The flipped classroom can be utilized through different content areas and may look slightly different depending on its use. As part of developing a curriculum, flipping a classroom may show more engagement of students during class time. No longer is the teacher the focal point of the class; the teacher can work with the whole class, small groups, or individuals, depending on the skill set of the students. Students can ask questions and receive instant feedback from the teacher as they hone their content skills. From an educator's view, engagement is more evident. It can be difficult during a traditional lecture to see who is truly comprehending, and who is copying notes, verbatim, without grasping what they are writing. If students have misconceptions in a flipped classroom, these can be more obvious through the work the students are performing, or the questions they are asking. The flipped classroom can be a more beneficial way for students to show what they know and leaves room for the teacher to work with students on what they do not know or are struggling to conceptualize.

Final Thoughts

The idea of a flipped classroom can work two-fold: as a way to introduce a new topic and as a resource for alternative learning. Students no longer have to physically be present in a classroom to receive direct instruction. In a world where technology integration is growing, this is essential in a class setting. In the current climate where many schools have extended closures, this is possibly where the flipped classroom can come to the forefront of education. Students can continue to receive instruction from outside of the school from their teacher.

References

Altemueller, L., & Lindquist, C. (2017). Flipped classroom instruction for inclusive learning. *British Journal of Special Education*, *44(3),* 341-358.

Leo, J., & Puzio, K. (2016). Flipped instruction in a high school science classroom. *Journal of Science Education & Technology*, *25(5),* 775-781.

Miles, C., & Fogget, K. (2016). Supporting our students to achieve academic success in the unfamiliar world of flipped and blended classrooms. *Journal of University Teaching & Learning Practice*, *13(4),* 1-14.

Pérez, A., Collado, J., García de los Salmones, M., Herrero, A., & Martín, H. (2019). An empirical exploration of the perceived effectiveness of a 'flipped classroom' in a business communication course. *Journal of the Scholarship of Teaching & Learning*, *19(2),* 47-65.

Sezer, B. (2017). The effectiveness of a technology-enhanced flipped science classroom. *Journal of Educational Computing Research*, *55(4),* 471-494.

About the Author

Shawn Luce received his bachelor's degree in Chemistry with a concentration in Secondary Education from Westfield State University in spring 2016. He is currently enrolled in Bridgewater State University's MAT in Physical Science program and is expecting to complete his coursework during summer 2020. His research project was completed in the fall 2019 under the guidance of Professor J. Michael Bodi, Ph.D. Shawn plans to pursue either a Ph.D. or Ed.D. upon completion of the MAT program.

---

[1] **Editor's Notes:** This article describes an innovative chemistry curriculum. This is not a research study, and, as such, does not contain results and analysis of results sections.

[2] For the curriculum developed for this College 2 Chemistry course, chapters 7-9 from the course textbook were not used due to the developmental level of the students taking this course.